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MIAMI - FORT LAUDERDALE - WEST PALM BEACH AIR POLLUTANT EMISSION INVENTORY

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A summary of the Miami, Florida air pollution emission inventory is presented. The study area, which was chosen on the basis of the distribution of population and air pollution sources, consists of three counties surrounding the cities of Miami, Ft. Lauderdale, and West Palm Beach. This area had a 1968 population of 2,150,000. A grid coordinate system was used to show the geographical distribution of emissions within counties. The pollutants studied were: sulfur oxides, particulates, carbon monoxide, hydrocarbons and nitrogen oxides. All sources of emissions were classified into the following categories: transportation, stationary fuel combustion, solid waste disposal, industria processes and evaporative losses.

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MIAMI-FT. LAUDERDALE-WEST PALM BEACH METROPOLITAN AREA
AIR POLLUTANT EMISSION INVENTORY

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

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PREFACE

This report, which presents the emission inventory for the Miami-Ft. Lauderdale-West Palm Beach Metropolitan Area, is another in a series of surveys outlining the sources and emissions of air pollutants for major metropolitan areas in the country. These surveys, conducted by the National Inventory of Air Pollutant Emissions and Control Branch of the National Air Pollution Control Administration, provide estimates of the present levels of air pollutant emissions and status of their control. The pollutants, which include sulfur oxides, particulates, carbon monoxide, hydrocarbons and nitrogen oxides, are delineated with respect to source type, season of the year and geographical distribution within the area. The general procedure for the surveys is based upon the rapid survey technique for estimating air pollutant emissions.[1] These reports are intended to serve as aids in the proposing of boundaries of Air Quality Control Regions, as directed by the Air Quality Act of 1967.

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INTRODUCTION

This report is a summary of the Miami air pollutant emission inventory conducted in July 1969. Since all inventories are based upon a calendar year, the data and emission estimates presented are representative of 1968 and should be considered as indicating the conditions as existed during that year.

The Study Area, which was chosen on the basis of the distribution of population and air pollution sources, consists of three counties surrounding the cities of Miami, Ft. Lauderdale and West Palm Beach. This area covers approximately 5,300 square miles and had a 1968 population of 2,150,000, excluding approximately an average daily level of 260,000 tourists.

A grid coordinate system was used to show the geographical distribution of emissions within counties. The Study Area was subdivided into 66 grid zones ranging in size from 25 square kilometers in the heavily populated and industrialized areas to 1,600 square kilometers in the everglades region.

All sources of emissions were classified into five categories--transportation, stationary fuel combustion, solid-waste disposal, industrial processes and evaporative losses. Each of these source categories was divided into two subgroups--point sources and area sources. Facilities, which emit large quantities of air pollutants, were considered individually as point sources, while the many remaining contributors such as motor vehicles, residential and commercial fuel users, small industries and on-site refuse burning equipment, were considered collectively as area sources. For this report, fourty-four individual sources, which had emissions greater than 0.5 tons per average annual day for any pollutant, were classified as point sources.

Emissions were estimated by using various indicators such as fuel consumption, refuse burning rates, vehicle-miles, production data, and control efficiencies and emission factors relating these indicators to emission rates.[2] These factors represent average emission rates for

a particular source category. Since individual sources have inherent differences that cannot always be taken into consideration, discrepancies between the actual and estimated emissions are more likely in individual sources than in the total emissions for a source category.

As in all emission surveys, the data presented are estimates and should not be interpreted as absolute values. The estimates are, in some cases, partial totals due to the lack of emission factors and production or consumption data. Despite these limitations, these estimates are of sufficient accuracy and validity in defining the extent and distribution of air pollutant emissions in the Study Area.

SUMMARY

The annual emissions as estimated by the Miami Metropolitan Area Air Pollutant Emission Inventory are:

Sulfur Oxides	150,700
Particulates	67,900
Carbon Monoxide	1,043,000
Hydrocarbons	2,497,000
Nitrogen Oxides	109,000

The following is a brief description of the air pollutant emissions as presented in Table 1 and Table 2.

Sulfur Oxides: The largest portion of the sulfur oxides emitted came from the four steam-electric plants located in the Study Area which had oil fired units. Together these plants accounted for 85 percent of the total sulfur oxides. There were no other large individual sources of sulfur oxides, but the smaller sources and area sources such as industrial fuel consumption and motor vehicles accounts for the remaining 15 percent. This can easily be explained since these plants used over 90 percent of the total residual oil consumed in the area.

Particulates: The largest source of particulate emissions was the sugar cane industry. The harvesting of the sugar cane crop involves field burning. This along with the processing of the sugar at mills accounted for 51 percent of total particulates.
Two cement plants in Dade County were the second largest sources in the Area accounting for approximately

17 percent of total emissions. Other sources included stationary fuel combustion, transportation, and refuse disposal which accounted for 15, 8 and 9 percent respectively of total emissions.

Carbon Monoxide: Motor vehicles contributed 87 percent of the carbon monoxide emitted annually. Other transportation sources included railroads, aircraft, and vessels, which collectively accounted for 8 percent of the total carbon monoxide. The only other significant source of carbon monoxide was the field burning of the sugar cane which contributed 5 percent to the total carbon monoxide.

Hydrocarbons: The Study Area was unique from this standpoint. Throughout the western section of all three counties there is a big percentage of land which is swamps. These swamps generate methane and it is given off into the atmosphere. Even though methane is an unreactive hydrocarbon, it was included under total hydrocarbons and as a result 93 percent of total hydrocarbons came from the methane emitted in the swamp gas. Motor vehicles and evaporative loss sources were the most significant sources of reactive hydrocarbons each accounting for 3 percent of total hydrocarbons.

Nitrogen Oxides: The two largest sources of nitrogen oxides were the steam-electric utilities and motor vehicles, each accounting for 42 percent of the total. Railroads, aircraft, and vessels accounted for 8 percent of total emissions. The other 8 percent was divided among stationary fuel combustion sources, solid-waste disposal and industrial process sources.

TABLE 1 SUMMARY OF AIR POLLUTANT EMISSIONS IN THE MIAMI - FORT LAUDERDALE - WEST PALM BEACH STUDY AREA, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Motor Vehicles	3,930	6,860	904,300	69,100	46,000
Other	3,530	3,440	78,000	18,100	8,300
Subtotal	7,460	10,300	982,300	87,200	54,300
Stationary Fuel Combustion					
Industry	10,700	800	70	70	3,000
Steam-Electric	127,500	3,700	10	1,030	46,000
Residential	100	160	N	N	1,000
Commercial and Institutional	3,700	440	40	40	2,000
Subtotal	142,000	5,100	120	1,140	52,000
Refuse Disposal					
Incineration	1,150	5,380	2,760	200	1,200
Open Burning	40	610	3,270	1,150	420
Subtotal	1,190	5,990	6,030	1,350	1,620
Industrial Process Losses	N	46,500	54,700	6,600	1,100
Evaporative Losses	--	--	--	73,500	--
Miscellaneous[a]	--	--	--	2,327,000	--
GRAND TOTAL[b]	150,700	67,900	1,043,000	2,497,000	109,000

N = Negligible

a = Includes only the methane emitted from swamp gas.

b = Totals have been rounded.

TABLE 2 PERCENTAGE CONTRIBUTION OF ALL SOURCES TO TOTAL EMISSIONS

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Transportation					
Motor Vehicles	2.6	10.1	86.7	2.8	42.2
Other	2.4	5.1	7.5	0.7	7.6
Subtotal	5.0	15.2	94.2	3.5	49.8
Stationary Fuel Combustion					
Industry	7.1	1.2	N	N	2.8
Steam-Electric	84.6	5.5	N	N	42.2
Residential	N	0.2	N	N	0.9
Commercial and Institutional	2.5	0.6	N	N	1.8
Subtotal	94.2	7.5	N	N	47.7
Refuse Disposal					
Incineration	0.8	7.9	0.3	N	1.1
Open Burning	N	0.9	0.3	N	0.4
Subtotal	0.8	8.8	0.6	N	1.5
Industrial Process Losses	N	68.5	5.2	0.3	1.0
Evaporative Losses	--	--	--	2.9	--
Miscellaneous	--	--	--	93.3	--
GRAND TOTAL	100	100	100	100	100

DESCRIPTION OF STUDY AREA

The Study Area for the emission survey of the Miami Metropolitan Area consists of three counties--Broward County, Dade County and Palm Beach County. The three-county area is located in the south eastern tip of Florida. Figure 1 shows the location of the Miami Study Area relative to other large cities in its vicinity.

Figure 2 represents a more detailed drawing of the Miami Study Area, showing the boundaries of the major urban areas. It should be pointed out that the boundaries of these areas do not correspond to city limits, but rather give a general outline of the major clusters of population. The Study Area occupies 5,280 square miles and contained an estimated 1968 population of 2,150,000 which is approximately a 43 percent increase since 1960 (Table 3).[3] As is pointed out in Table 3 an accurate population figure for this area must take into consideration the addition of 265,000 tourists on any given day in the year on the average. The population density map (Figure 3) shows that the heaviest population is concentrated primarily in and near the city of Miami, with heavy concentrations also in Ft. Lauderdale and West Palm Beach.

TOPOGRAPHY AND CLIMATOLOGY

The Miami Study Area is located on the lower east coast of Florida. The entire area is bound to the east by the Atlantic Ocean and to the west by the Everglades region. To the east of Miami lies Biscayne Bay, about 15 miles long and 3 miles wide. East of the bay is the island of Miami Beach, a mile or less wide and about ten miles long, and beyond Miami Beach is the Atlantic Ocean. West Palm Beach and Palm Beach are located on the coastal sand ridge of southeastern Florida. The entire coastal ridge is only about 2 1/2 miles wide, and in early times the Everglades reached to its western edge. Now much of the swampland has been drained and is devoted to agriculture.

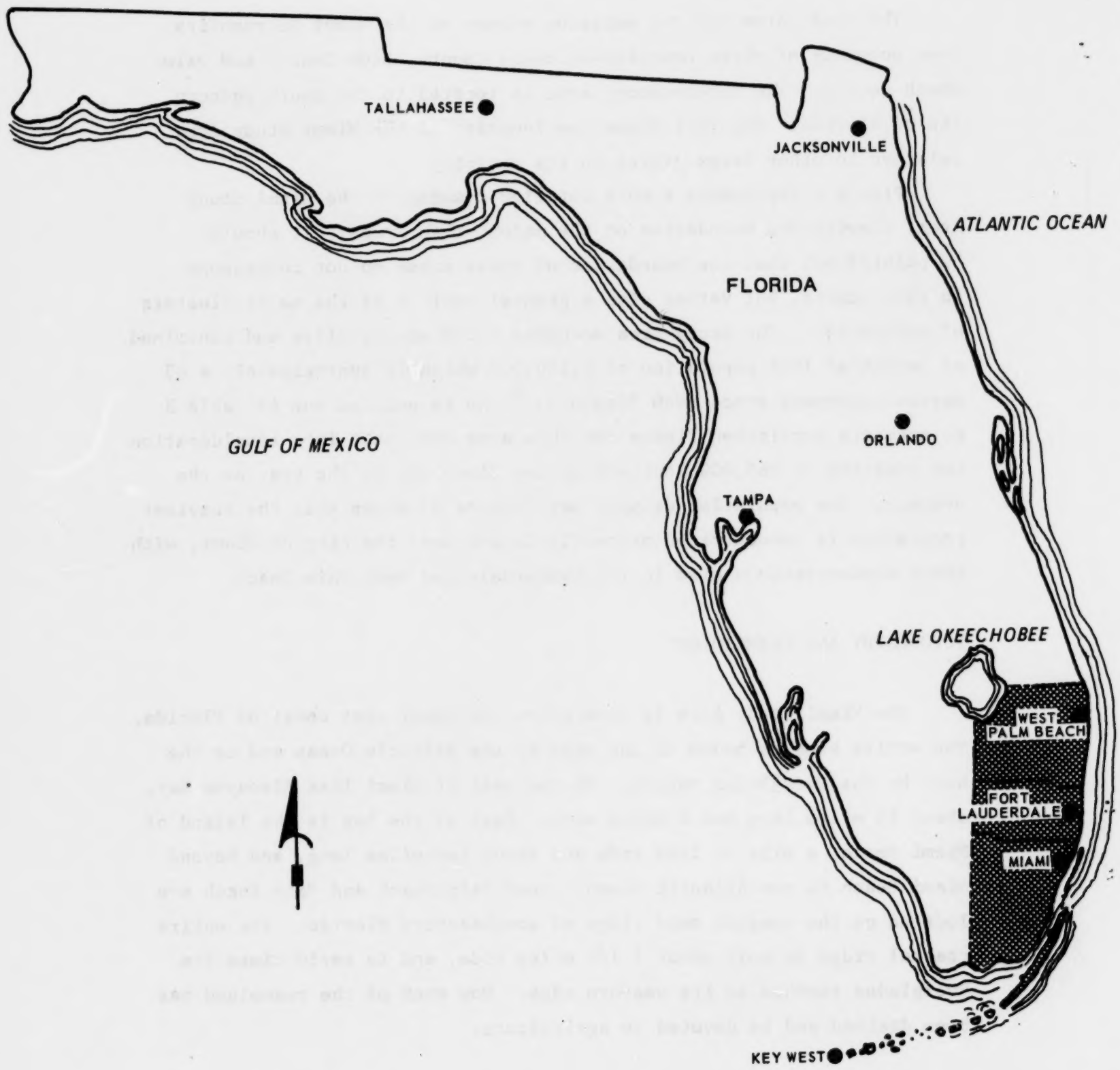

Figure 1. Map of the state of Florida showing the Miami - Fort Lauderdale - West Palm Beach study area.

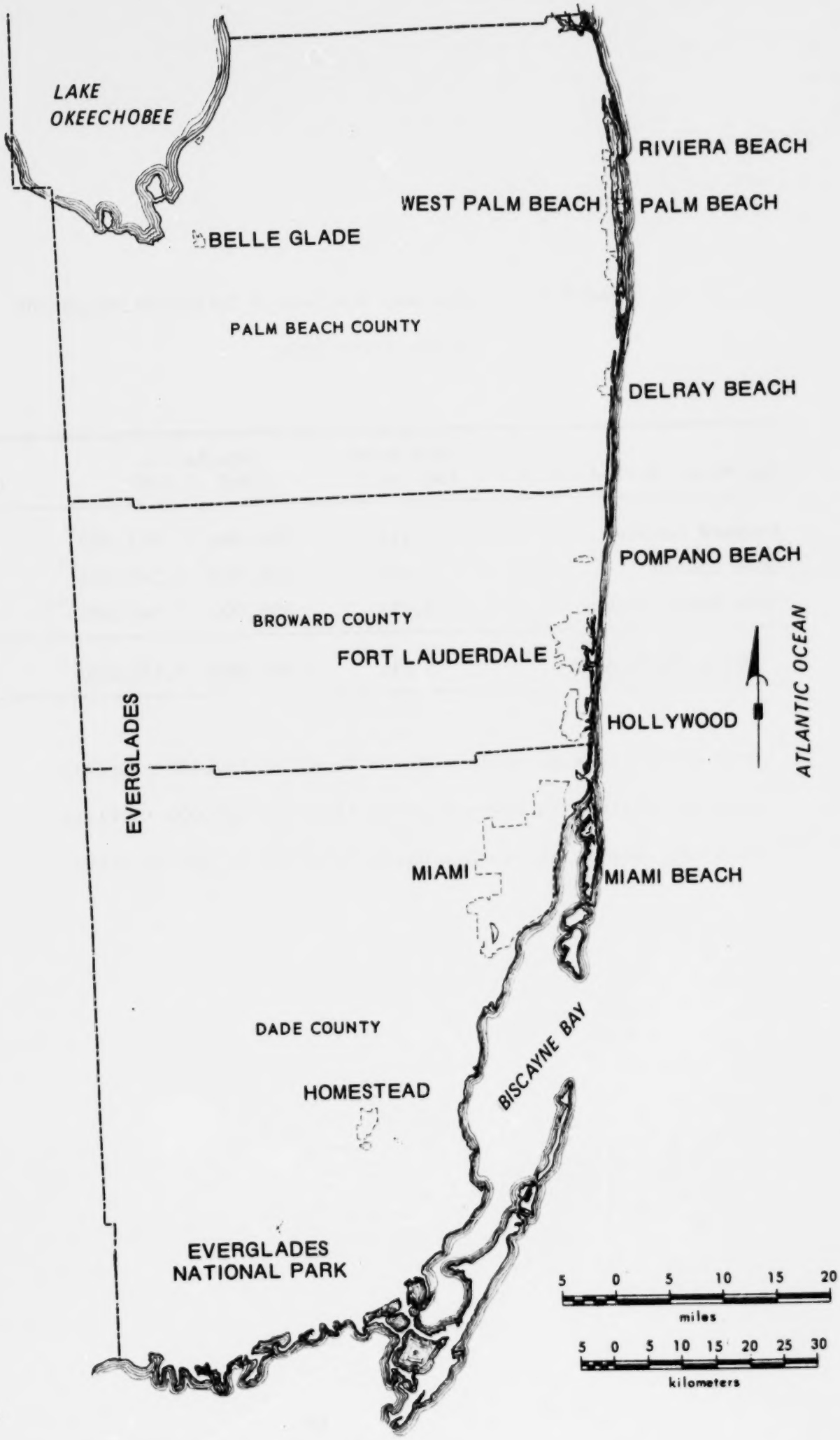

Figure 2. Detailed Map of Miami Study Area

TABLE 3 AREA AND POPULATION CHARACTERISTICS FOR MIAMI STUDY AREA

Political Jurisdiction	Land Area (sq. mi.)	Population 1960	Population 1968	Population Density (1968)
Broward County	1,219	334,000	567,000*	465
Dade County	2,042	935,000	1,240,000**	607
Palm Beach County	2,023	228,000	345,000***	170
TOTAL STUDY AREA	5,284	1,497,000	2,152,000	407

* Does not include an average daily level of 100,000 tourists

** Does not include an average daily level of 140,000 tourists

*** Does not include an average daily level of 25,000 tourists

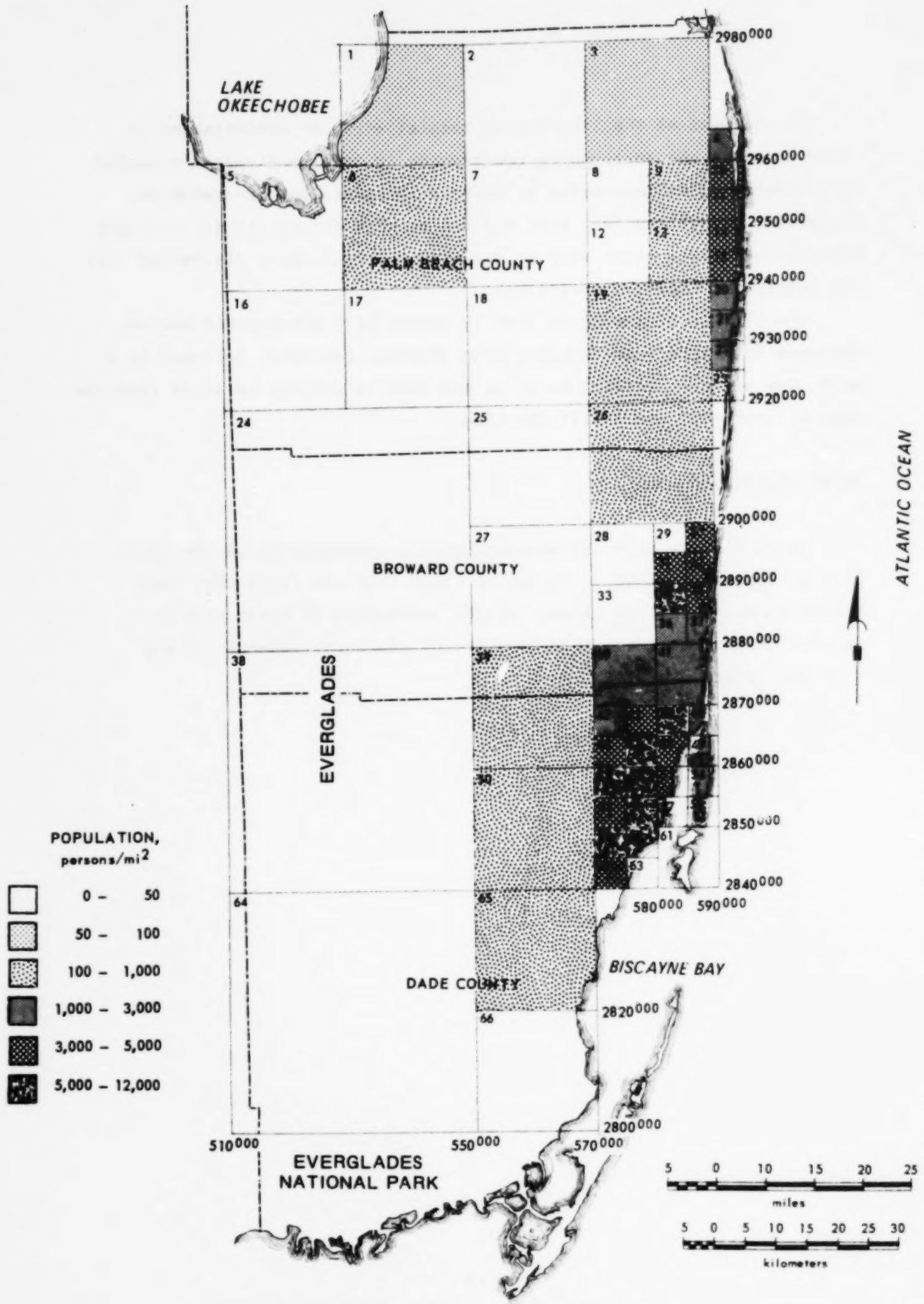

Figure 3. Population densities for Miami study area.

To the west of the long narrow coastal strip of urbanization in these counties the surrounding countryside is level and sparsely wooded. This absence of any mountains or hills make conditions favorable for dispersion of pollutants. Also the sea breezes during the day and land breezes during the night help to disperse the pollutants discharged into the atmosphere near the coastline.

The climate of the Study Area is essentially subtropical marine, featured by a long, warm summer, with abundant rainfall, followed by a mild, dry winter. Located as it is the area is subject to winds from the east or southeast about half the time.

MAJOR INDUSTRIAL

Table 4 shows selected manufacturing establishments in the Study Area by county for 1963.[4] It may be noted from the table that Dade County accounts for the largest single percentage of every type of manufacturing. At least fifty percent of the establishments of any type are located in Dade County.

TABLE 4 SELECTED MANUFACTURING ESTABLISHMENTS IN THE STUDY AREA, 1963

Establishments with 20 or More Employees	Broward	Dade	Palm Beach	Total
Food and Tobacco	8	72	20	100
Textile and Apparel	12	131	1	144
Paper and Printing	8	62	4	74
Chemicals	9	24	5	38
Lumber Products	15	60	10	85
Stone Clay and Glass	17	25	11	53
Metal Products	7	77	2	86
Machinery	22	30	5	57
Transportation	12	29	4	45
TOTAL	110	510	62	682

GRID COORDINATE SYSTEM

A grid coordinate system, based on the Universal Transverse Mercator Projection (UTM) was used in the Miami Study Area to show the geographical distribution of emissions. A map of this grid system is presented in Figure 4.

The UTM system was chosen due to its advantages over other standard grid systems such as the Latitude-Longitude and State Plane Coordinate Systems. The major advantages of this system are that (1) it is continuous across the country and is not hindered by political subdivision, (2) the grids are of uniform size throughout the country, (3) it has world-wide use, and (4) the grids are square in shape--a necessary feature for use in meteorological dispersion models.

The Universal Transverse Mercator Projection is based upon the metric system. Each north-south and east-west grid line, as illustrated in Figure 4, is identified by the horizontal and vertical coordinates of their geographical center to the nearest 100 meters.

As shown in Figure 4, the Study Area was divided into 66 grids of four different sizes--25, 100, 400, and 1,600 square kilometers. Grid zones of different sizes are used to limit the number of grid zones and yet allow a satisfactory definition of the geographical gradation of emissions. The majority of the emissions is usually concentrated in the populated and industrialized portions of a Study Area. Smaller grids are placed over these areas in order to reflect abrupt changes in emissions within short distances. The use of grid zones smaller than 25 square kilometers is not warranted because of the inherent inaccuracies in the data. Since only a small percentage of the total emissions occur in rural areas, larger grid zones are normally used to show the distribution of emissions in these lightly populated portions of a Study Area.

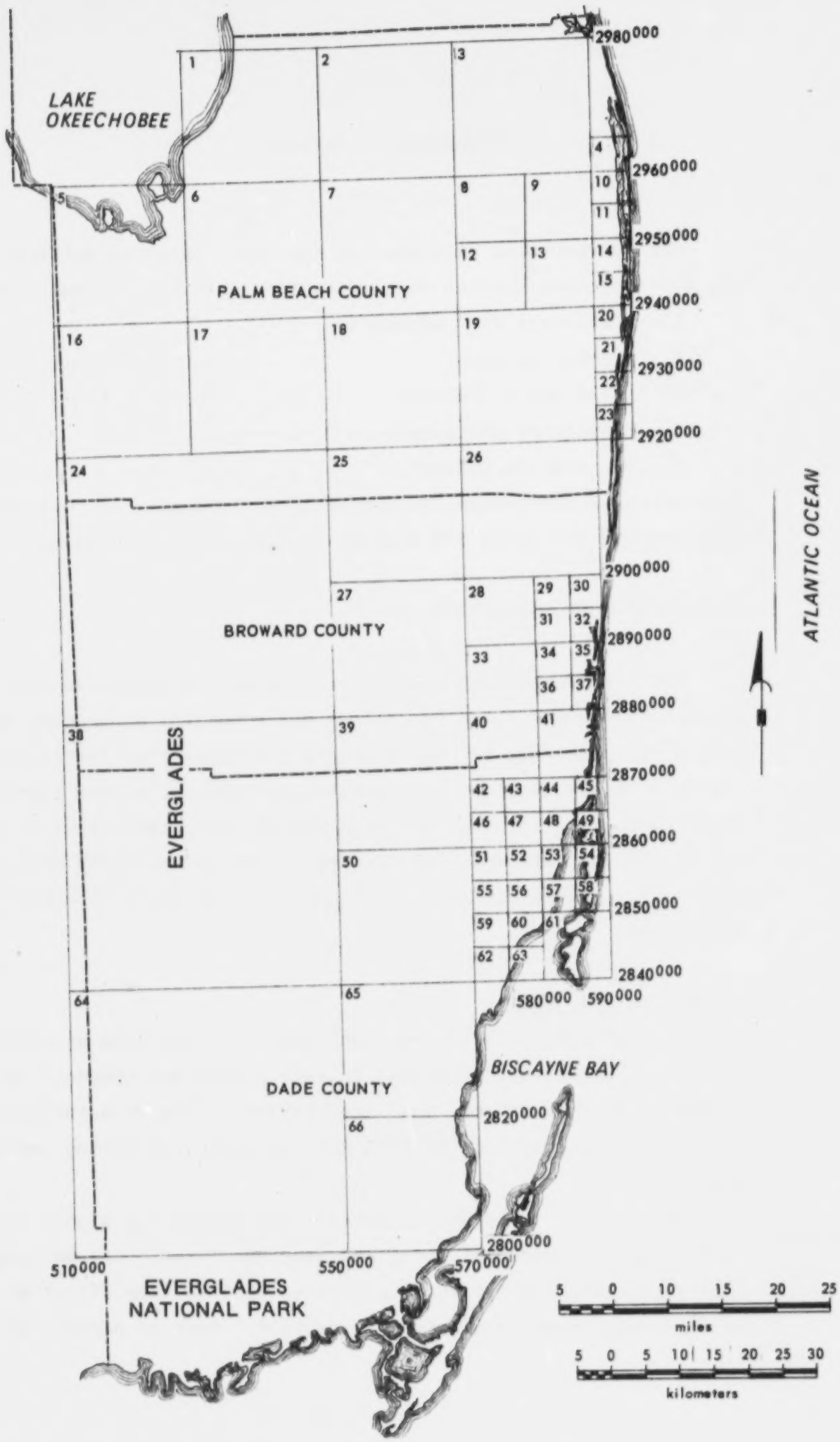

Figure 4. Grid Coordinate System for Miami Study Area

EMISSIONS BY CATEGORY

For the purposes of compiling the basic data and emission estimates, the air pollutant sources were classified into the following five categories:

1. Stationary fuel combustion
2. Transportation
3. Solid Waste Disposal
4. Industrial Processes
5. Evaporative Losses

Each of these categories is considered individually in this section where data sources are given and methods of calculation discussed.

STATIONARY FUEL COMBUSTION

The stationary fuel combustion category is concerned with any fixed source which burns fuels for either space heating or process heating. The four primary sources in this category are industrial facilities, steam-electric plants, residential housing, and commercial and institutional establishments. In the Miami area natural gas, residual fuel oil, distillate fuel oil and liquified petroleum gas were the most widely used fuels. Table 5 presents a summary of the fuels consumed in the Study Area.

Steam-Electric Utility

METHODOLOGY: Data on the power plants in the area was acquired from the Health Department officials in each county and compared to figures presented by the National Coal Association.[5] The data included the annual fuel consumption for 1968 and the method of firing employed at each plant.

RESULTS: Of the eight steam-electric generating plants in the Study Area four were oil fired and four gas fired. Air pollutant emissions from fuel combustion at these plants as well as from all other fuel combustion sources are summarized in Table 6. Over 89 percent of the total

TABLE 5 ANNUAL FUEL CONSUMPTION IN POLITICAL SUBDIVISIONS OF THE MIAMI STUDY AREA, 1968

Political Jurisdiction	Industrial	Residential	Steam Electric	Commercial & Institutional	TOTAL
Residual Fuel Oil 1000 gal./yr.					
Broward	NA	--	288,700	NA	288,700
Dade	32,000	--	213,300	23,800	269,100
Palm Beach	11,500	--	139,200	1,140	151,840
TOTAL	43,500	--	641,200	24,940	709,640
Distillate Fuel Oil 1000 gal./yr.					
Broward	NA	1,090	--	NA	1,090
Dade	2,700	5,000	770	3,500	11,970
Palm Beach	15,200	1,990	570	13,000	30,760
TOTAL	17,900	8,080	1,340	16,500	43,820
Natural Gas Million CF/yr.					
Broward	50	180	33,300	620	34,150
Dade	3,140	400	16,700	7,000	27,240
Palm Beach	800	110	14,600	960	16,470
TOTAL	3,990	690	64,600	8,580	77,860
Liquid Petroleum Gas 1000 gal.					
Broward	NA	14,200	--	NA	14,200
Dade	4,200	24,500	--	6,300	35,000
Palm Beach	NA	6,600	--	NA	6,600
TOTAL	4,200	45,300	--	6,300	55,800

TABLE 6 SUMMARY OF EMISSIONS FROM STATIONARY FUEL COMBUSTION
MIAMI STUDY AREA, 1968 (Tons/Year)

Fuel User Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Fuel Oil					
Industrial	10,700	720	70	70	2,480
Steam-Electric	127,500	3,210	10	1,030	33,400
Residential	100	10	N	N	10
Commercial and Institutional	3,700	410	40	40	1,490
Subtotal	142,000	4,350	120	1,140	37,380
Natural Gas					
Industrial	N	40	N	N	430
Steam-Electric	10	490	N	N	12,600
Residential	N	20	N	N	110
Commercial and Institutional	N	80	N	N	500
Subtotal	10	630	N	N	13,640
LPG					
Industrial	N[a]	10	N	N	90
Steam-Electric	N	N	N	N	N
Residential	N	110	N	N	880
Commercial and Institutional	N	30	N	N	130
Subtotal	N	150	N	N	1,100
GRAND TOTAL[b]	142,000	5,100	120	1,140	52,100

a N = Negligible

b Totals have been rounded

sulfur oxides from stationary fuel combustion, 63 percent of the particulates, 8 percent of the carbon monoxide, 90 percent of the hydrocarbons, and 88 percent of the nitrogen oxides were attributed to these eight plants. Except for nitrogen oxides the emissions came almost entirely from the four oil fired plants. For nitrogen oxides 64 percent came from the oil fired plants and 24 percent from the gas fired plants.

Industrial

METHODOLOGY: Natural Gas numbers were obtained from each of the local gas companies who provided the breakdown by user category. Total fuel oil usage was determined through contacts with fuel oil dealers and suppliers and through data furnished by the Port authorities. Specific data on the quantity of fuels used by the largest industrial sources were provided by the local air pollution agencies who had contacted each plant.

RESULTS: The majority of the emissions from stationary fuel combustion at industrial plants was from the consumption of fuel oil. Industrial sources accounted for 8 percent of the total sulfur oxides from stationary fuel combustion, 14 percent of the particulates, 58 percent of the carbon monoxide, 6 percent of the hydrocarbons and 5 percent of the nitrogen oxides.

Residential

METHODOLOGY: Natural gas, LPG, and distillate fuel oil, for all practical purposes, were the only fuels used for residential home heating. There were homes heated by other methods, but they represent a very small percentage of the total. Data on the quantities of natural gas and fuel oil used for domestic heating was supplied by the local air pollution agencies and compared with the rapid survey technique of estimating the fuel used for residential heating.[6] LPG consumption data was estimated based on the rapid survey technique.

RESULTS: The emissions from residential sources were insignificant except for particulates, of which 11 percent of the total fuel combustion emissions were from home heating.

Commercial and Institutional

METHODOLOGY: Commercial and institutional establishments in the Study Area used all four of the previously mentioned fuels--distillate and residual oil, natural gas and LPG. Data on the total amounts of these fuels used in the area as well as the consumption at individual establishments was supplied by the local air pollution agencies.

RESULTS: The use of fuel oil at commercial and institutional establishments was by far the most significant source of emissions from this category. The contribution to total stationary fuel combustion emissions from these establishments was relatively minor, amounting to less than 5 percent for any one pollutant.

TRANSPORTATION

Four types of transportation sources of air pollution are considered in this survey--motor vehicles, aircraft, vessels and railroads. Motor vehicles, which are by far the most significant source in this category, are further subdivided according to type of fuel--gasoline or diesel.

Motor Vehicles

More than 26 million miles were traveled per day by motor vehicles in 1968 in the Miami Study Area. In the process, 670 million gallons of gasoline and 56 million gallons of diesel fuel were consumed annually for highway purposes. Table 7 shows the miles of travel for gasoline and diesel vehicles for each county in the Study Area.

Vehicle mile data for all three counties was supplied by Mel Conner and Associates Consulting Engineers, who had conducted extensive traffic surveys. This data in conjunction with traffic flow maps showing average daily traffic along most roads and other information provided by the Florida State Road Department were used to determine the distribution of traffic in the Study Area.

The contribution to the total motor vehicle pollution by diesel-powered vehicles was determined by assuming that approximately three

TABLE 7 VEHICLE MILES OF TRAVEL FOR MOTOR VEHICLES IN MIAMI STUDY AREA PER DAY FOR 1968

Jurisdiction	Gasoline Vehicle Miles	Diesel Vehicle Miles	Total
Broward	7,760,000	240,000	8,000,000
Dade	12,804,000	396,000	13,200,000
Palm Beach	5,044,000	156,000	5,200,000
Totals	25,608,000	792,000	26,400,000

percent of the total vehicle miles traveled were by diesel-powered vehicles. This was checked by estimating diesel fuel consumption in each county.[7] These emissions were apportionned on a grid basis by assuming they were proportional to gasoline emissions.

Emissions from motor vehicles are a function of the speed at which the vehicle travels. Average speeds of 10-20 mph were assumed for downtown areas, 20-30 mph for the residential areas, and 30-45 mph for the rural areas to calculate vehicle emissions.

From all transportation sources, motor vehilces accounted for 53 percent of sulfur oxides, 67 percent of the particulates, 92 percent of the carbon monoxide, 79 percent of the hydrocarbons and 85 percent of the nitrogen oxides. Gasoline powered motor vehicles contributed a greater percent of all pollutants than diesel powered motor vehicles. Emissions from transportation sources are summarized in Table 8.

Aircraft

Table 9 shows the air traffic activity at the nine largest airports in the Study Area. An estimate of the number of flights by engine type was supplied by the traffic controller at each airport and summarized in this table.

The air pollutant emissions from aircraft include all phases of operation (taxi, take-off, climb out, approach and landing) that take place below the arbitrarily chosen altitude of 3,500 feet. Emissions of cruise altitude (above 3,500 feet) are not of concern in an emission inventory. From all transportation sources, aircraft accounted for 17 percent of the particulates, 8 percent of the carbon monoxide, 19 percent of the hydrocarbons and 8 percent of the nitrogen oxides.

Railroads and Vessels

Railroad operations (mainly locomotive) consume about 8 million gallons of diesel fuel per year within the Study Area. This quantity is about 85 percent less than the amount of diesel fuel consumed by motor vehicles. The majority of this fuel is consumed during switching operations. Diesel fuel consumption data were supplied by each of the major railroads in the Miami area. Approximately 2 million gallons of diesel fuel and 3 million gallons of residual oil were consumed by river vessel traffic along the Atlantic Coast.

TABLE 8 SUMMARY OF AIR POLLUTANT EMISSIONS FROM TRANSPORTATION SOURCES, 1968 (Tons/Year)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Motor Vehicles					
Gasoline	2,800	3,740	902,600	65,300	39,700
Diesel	1,130	3,120	1,700	3,800	6,300
Evaporation					
Subtotal	3,930	6,860	904,300	69,100	46,000
Aircraft					
Jet	--	1,380	1,800	1,790	1,100
Piston	--	360	75,300	14,400	3,510
Turboprop	--	10	30	10	20
Subtotal	--	1,750	77,130	16,200	4,630
Railroads	160	440	240	540	900
Vessels	3,370	1,250	610	1,370	2,760
GRAND TOTAL[a]	7,460	10,300	982,300	87,200	54,300

a Totals have been rounded

TABLE 9 AIR TRAFFIC ACTIVITY AT THE LARGEST AIRPORTS IN THE MIAMI STUDY AREA, 1968

(Number of Flights Per Year)

Airport	Conventional Jet				Fan Jet			Turboprop		Piston			Total
	Single Engine	Twin Engine	Three Engine	Four Engine	Twin Engine	Three Engine	Four Engine	Twin Engine	Four Engine	Single Engine	Twin Engine	Four Engine	
Miami International	--	13,000	15,200	19,600	21,800	38,100	49,000	--	--	18,200	29,900	11,000	215,800
Opa Locka	--	4,400	--	--	--	--	--	--	--	223,200	54,200	--	281,800
Tamiami	--	2,200	--	--	--	--	--	--	--	151,400	65,800	--	219,400
Hollywood-Ft. Lauderdale	3,500	3,100	--	3,100	1,200	7,100	3,600	7,200	1,000	136,200	93,000	--	259,300
North Perry	--	--	--	--	--	--	--	--	--	166,000	12,500	--	178,500
Pompano Beach	--	--	--	--	--	--	--	--	--	40,400	3,000	--	43,400
Palm Beach	--	13,300	--	--	3,500	13,900	--	--	8,800	57,500	8,800	--	105,800
Lantana	--	--	--	--	--	--	--	--	--	21,600	2,400	--	24,000
Executive	--	8,300	--	--	--	--	--	--	--	41,700	22,500	--	72,500
Total	3,500	44,300	15,200	22,700	26,500	59,100	52,600	7,200	9,800	856,200	292,100	11,000	1,400,500

Flight = Combination of landing and takeoff

This was estimated from information provided by the Port Authorities in each county.

Railroad and vessel operations collectively contribute about 47 percent of the sulfur oxides from all transportation sources, 16 percent of the particulates, 7 percent of the nitrogen oxides and less than 2 percent of the carbon monoxides or hydrocarbons.

SOLID WASTE DISPOSAL

Approximately 3.1 million tons of refuse was generated during 1968 within the Study Area. Table 10 presents a solid waste balance for the Miami Study Area, showing the various methods of disposal and the quantities disposed of by each method. The bulk of the refuse in Broward County and Dade County was disposed of in non-burning dumps and municipal incinerators, whereas in Palm Beach County non-burning dumps alone were the biggest method of disposal. Refuse data for all of the counties were supplied by each air pollution agency.

Incineration

The two major categories of incineration in the Miami Study Area are municipal, and on-site. On-site and municipal incinerators together disposed of about 34 percent of the generated refuse. Only about 1 percent of this was from the on-site (supermarket, commercial building) type incinerator.

The contributions of each of these incineration categories to total solid waste emissions are shown in Table 11. Municipal incineration is by far the most significant category, contributing 88 percent of the total sulfur oxide emissions from all solid waste sources, 81 percent of the particulates, 65 percent of the carbon monoxides. The largest point sources in the Study Area were four municipal incinerators in Broward County and three in Dade County.

TABLE 10 SOLID WASTE BALANCE FOR THE MIAMI STUDY AREA, 1968 (TONS/YEAR)

Political Jurisdiction	Total Refuse Generated	Incineration		Dumps	
		Municipal	On-Site	Open Burning	No Open Burning
Broward County	852,000	456,000	10,000	20,000	366,000
Dade County	1,802,000	590,000	12,000	N	1,200,000
Palm Beach County	473,000	--	8,000	73,000	392,000
TOTALS	3,127,000	1,046,000	30,000	93,000	1,958,000

N = Negligible

TABLE 11 AIR POLLUTANT EMISSIONS FROM SOLID WASTE DISPOSAL IN THE MIAMI STUDY AREA (Tons/Year)

Source Category	Sulfur Oxides	Particulates	Carbon Monoxide	Hydrocarbons	Nitrogen Oxides
Incineration					
Municipal	1,050	4,870	520	160	1,050
On-site	100	510	2,240	40	150
Subtotal	1,150	5,380	2,760	200	1,200
Open Burning					
On-site	--	--	--	--	--
Dump	40	610	3,270	1,150	420
Subtotal	40	610	3,270	1,150	420
GRAND TOTAL	1,190	5,990	6,030	1,350	1,620

Open Burning

The two major categories of open burning are usually open burning dumps and on-site open burning. However, due to strict local ordinances on-site open burning is practically non-existent. Open burning dumps are thus the only contributors to the air pollution from open burning. They account for 3 percent of the sulfur oxides from all solid waste, 10 percent of the particulates, 54 percent of the carbon monoxide, 85 percent of the hydrocarbons, and 25 percent of the nitrogen oxides. The largest open burning point sources in the Study Area were six open burning dumps in Palm Beach County and one open burning dump in Broward County.

INDUSTRIAL PROCESSES

The Study Area is notably void of any heavy industrial complexes. From an air pollution standpoint the field burning associated with the harvesting of sugar cane was the most significant source. The processing of this sugar at the sugar cane mills was the second largest source. Other minor sources in the food and agricultural category included 10 small coffee roasting plants. The major sources in the mineral products industry were two large cement plants in Dade County. A number of small asphalt batching plants in each of the three counties were less significant sources. Three small scale grey iron foundries in Dade County were the only other significant sources from an industrial process standpoint. Table 12 presents a summary of the emissions from the various industrial processes.

Palm Beach County is a large sugar producing county. All of the sugar cane harvested in the Study Area is in this county (approximately 5 million tons in 1968, gross yield). The sugar cane is harvested throughout the county by the burning of the crop. Unwanted foilage and other combustibles are burned up leaving the useable stock. This field burning of the sugar cane accounts for 19 percent of the total particulates from industrial processes, and 100 percent of the carbon monoxide, hydrocarbons and nitrogen oxides. The processing of the sugar cane at the mills is another large source of particulates accounting for 56 percent of the

TABLE 12 SUMMARY OF AIR POLLUTANT EMISSIONS FROM INDUSTRIAL PROCESS LOSSES, 1968 (Tons/Year)

Type Industry	Particulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Food and Agricultural				
Coffee Roasting	20	--	--	--
Sugar Cane Mills	26,100	--	--	--
Field Burning of Sugar Cane	8,700	54,700	6,600	1,100
Subtotal	34,820	54,700	6,600	1,100
Mineral Products				
Cement	11,240	--	--	--
Asphalt	420	--	--	--
Subtotal	11,660	--	--	--
Secondary Metals				
Grey Iron Foundry	40	--	--	--
GRAND TOTALS[a]	46,500	54,700	6,600	1,100

a Totals have been rounded.

total from industrial processes.

The only other significant sources in the industrial process category were the two cement plants in Dade County which account for 25 percent of the particulates.

EVAPORATIVE LOSSES

Three source categories were sonsidered for evaporative losses--automobiles, gasoline storage and handling, and the consumption of solvents. The hydrocarbon emissions from all sources by evaporative losses are shown in Table 13.

Automobiles

Automobile evaporation losses include gas tank and carburetor evaporation and engine crankcase blowby. Since 1963, most new automobiles were equipped with positive crankcase ventilation (PCV) valves that reduce hydrocarbon emissions from the crankcase by about 90 percent. Due to a lag time in the automobile replacement rate, it was assumed that 20 percent of the automobiles were not equipped with PCV valves.

The hydrocarbon emissions from automobiles were calculated from vehicle-mile data and were apportionned onto grids using the same methods as for motor vehicles discussed earlier. Evaporative losses from automobiles accounted for 54 percent of the total hydrocarbon emissions from evaporative losses in the Study Area.

Gasoline Storage and Handling

There are four major points (excluding evaporation from the motor vehicle) of hydrocarbon emissions in the storage and handling of gasoline. They are:

1. Breathing and filling losses from storage tanks
2. Filling losses from loading tank conveyances
3. Filling losses from loading underground storage tanks at service stations
4. Spillage and filling losses in filling automobile gas tanks at service stations.

TABLE 13 HC EMISSIONS FROM EVAPORATIVE LOSSES IN THE MIAMI CITY STUDY AREA, 1968 (Tons/Year)

Type of Source	HC Emissions
Motor Vehicles	39,300
Solvent Usage	
Industrial	16,900
Dry Cleaning	4,700
Domestic and Commercial	3,500
Subtotal	25,100
Gasoline Storage and Handling	9,100
GRAND TOTAL	73,500

Approximately 670 million gallons of gasoline was stored in the Study Area in 1967. The evaporative losses from this storage and the subsequent handling of the gasoline accounted for 12 percent of the total evaporative losses.

Consumption of Solvents

This category included the consumption of solvents at dry cleaning plants, industrial solvent usage and the miscellaneous use of solvents by small commercial establishments and domestic units. Organic solvents emitted from these operations were determined by assuming an emission rate of 4 lb/capita/year for dry cleaning plants, 13 lb/capita/year for industries and 3 lb/capita/year for miscellaneous consumption.[8,9] The consumption of solvents by these three categories accounted for 34 percent of the hydrocarbon emissions from evaporative losses.

MISCELLANEOUS

The Miami area is unique from the standpoint that approximately 75 percent of the land contains swamps. These swamps and marsh land emit methane. Approximately 600 tons of methane are emitted per square mile of swamp land.[10] Even though this is an unreactive hydrocarbon it is still reported under total hydrocarbons. Based on the above emission factor, 2.3 million tons of methane were emitted in 1969 in the Miami Study Area. This represents 93 percent of total hydrocarbons.

EMISSIONS BY JURISDICTION

The previous section presented the air pollutant emissions by source category. In order to show the contribution of each county to the pollution in the entire Study Area, their emissions are summarized in Tables 14 through 16.

From an air pollution standpoint no one of the three counties in the Miami Study Area standout as being the most polluted. This is shown by the fact that sulfur oxides are emitted in greatest quantities in Broward County, particulates in Palm Beach County and carbon monoxide in Dade County. Significant quantities of all the five major pollutants are emitted in each of the three counties surveyed .

TABLE 14 SUMMARY OF EMISSIONS IN BROWARD COUNTY, 1968

(TONS/YEAR)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	1,200	2,100	242,800	19,200	13,900
Other	2,400	600	32,500	6,500	2,400
Subtotal	3,600	2,700	275,300	25,700	16,300
Stationary Fuel Combustion					
Industry	N	N	N	N	N
Steam-Electric	57,400	1,700	N	460	21,500
Residential	80	N	N	N	270
Commercial and Institutional	N	N	N	N	30
Subtotal	57,480	1,700	N	460	21,800
Refuse Disposal					
Incineration	460	2,400	450	70	470
Open Burning	10	160	850	300	110
Subtotal	470	2,560	1,300	370	580
Industrial Processes Losses	N	N	N	N	N
Evaporative Losses	--	--	--	21,600	--
Miscellaneous[a]	--	--	--	585,500	--
GRAND TOTAL[b]	61,600	6,800	276,600	633,600	38,700

N = Negligible

a = Includes only the methane emitted from swamp gas.

b = Totals have been rounded.

TABLE 15 SUMMARY OF EMISSIONS IN DADE COUNTY, 1968 (TONS/YEAR)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	1,970	3,430	484,400	36,300	23,000
Other	480	2,520	40,700	10,400	5,300
Subtotal	2,450	5,950	525,100	46,700	28,300
Stationary Fuel Combustion					
Industrial	7,880	660	40	40	1,940
Steam-Electric	42,400	1,200	N	340	14,400
Residential	--	10	N	N	600
Commercial and Institutional	3,300	390	30	30	1,520
Subtotal	53,580	2,260	70	410	18,460
Refuse Disposal					
Incineration	600	2,570	550	90	610
Open Burning	N	N	N	N	N
Subtotal	600	2,570	550	90	610
Industrial Process Losses	--	11,600	N	N	N
Evaporative Losses	--	--	--	38,600	--
Miscellaneous[a]	--	--	--	909,000	--
GRAND TOTAL[b]	56,700	22,400	525,700	994,800	47,400

N = Negligible

a = Includes only the methane emitted from swamp gas.

b = Totals have been rounded.

TABLE 16 SUMMARY OF EMISSIONS IN PALM BEACH COUNTY, 1968

(TONS/YEAR)

Source Category	Sulfur Oxides	Partic-ulates	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Transportation					
Motor Vehicles	770	1,350	177,100	13,560	9,060
Other	620	300	4,800	1,190	630
Subtotal	1,390	1,650	181,900	14,750	9,690
Stationary Fuel Combustion					
Industry	2,780	250	30	30	1,050
Steam-Electric	27,700	810	N	220	10,100
Residential	100	10	N	N	150
Commercial and Institutional	420	120	10	10	560
Subtotal	31,000	1,190	40	260	11,860
Refuse Disposal					
Incineration	80	400	1,760	30	120
Open Burning	30	450	2,420	850	310
Subtotal	110	850	4,180	880	430
Industrial Process Losses	N	34,900	54,700	6,600	1,100
Evaporative Losses	--	--	--	13,400	--
Miscellaneous[a]	--	--	--	832,600	--
GRAND TOTAL[b]	32,500	38,600	240,800	868,500	23,100

N = Negligible

a = Includes only the methane emitted from swamp gas.

b = Totals have been rounded.

EMISSIONS BY GRID

For the purpose or defining the geographical variation of air pollutant emissions in the Study Area, the resulting emissions were apportionned on the grid coordinate system. The emissions were divided into two source groups--point and area sources. Fourty-four point sources are identified individually with respect to location and emissions. Each of these point sources emitted more than 0.5 tons per average annual day of any pollutant.

CONTRIBUTIONS OF POINT AND AREA SOURCES

Figure 5 shows the location of all point sources in the area. Collectively the fourty-four point sources account for 92 percent of all sulfur oxides emissions, 72 percent of particulate matter, 49 percent of nitrogen oxides and only 8 percent of carbon monoxide and 1 percent of hydrocarbons. The percentage contribution to carbon monoxide emissions is low because motor vehicles, which are area sources, contribute 87 percent of the total carbon monoxide emissions. Similarly, the contribution to total hydrocarbon emissions is low since three groups of area sources, motor vehicles, evaporative losses, and swamp gas are the major sources. Table 17 presents the emissions of point sources. Each source is identified by source category, grid number and horizontal and vertical coordinates. The emissions of sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides are shown for an average annual day, average winter day (December, January, February), and average summer day (June, July, August). The appendix presents the method of calculating these three averages.

Area sources are sources of emissions that are insignificant by themselves, but as a group may emit a large portion of the areas total pollution. Examples of area sources are motor vehicles, residences, light commercial and industrial establishments and backyard burning. The

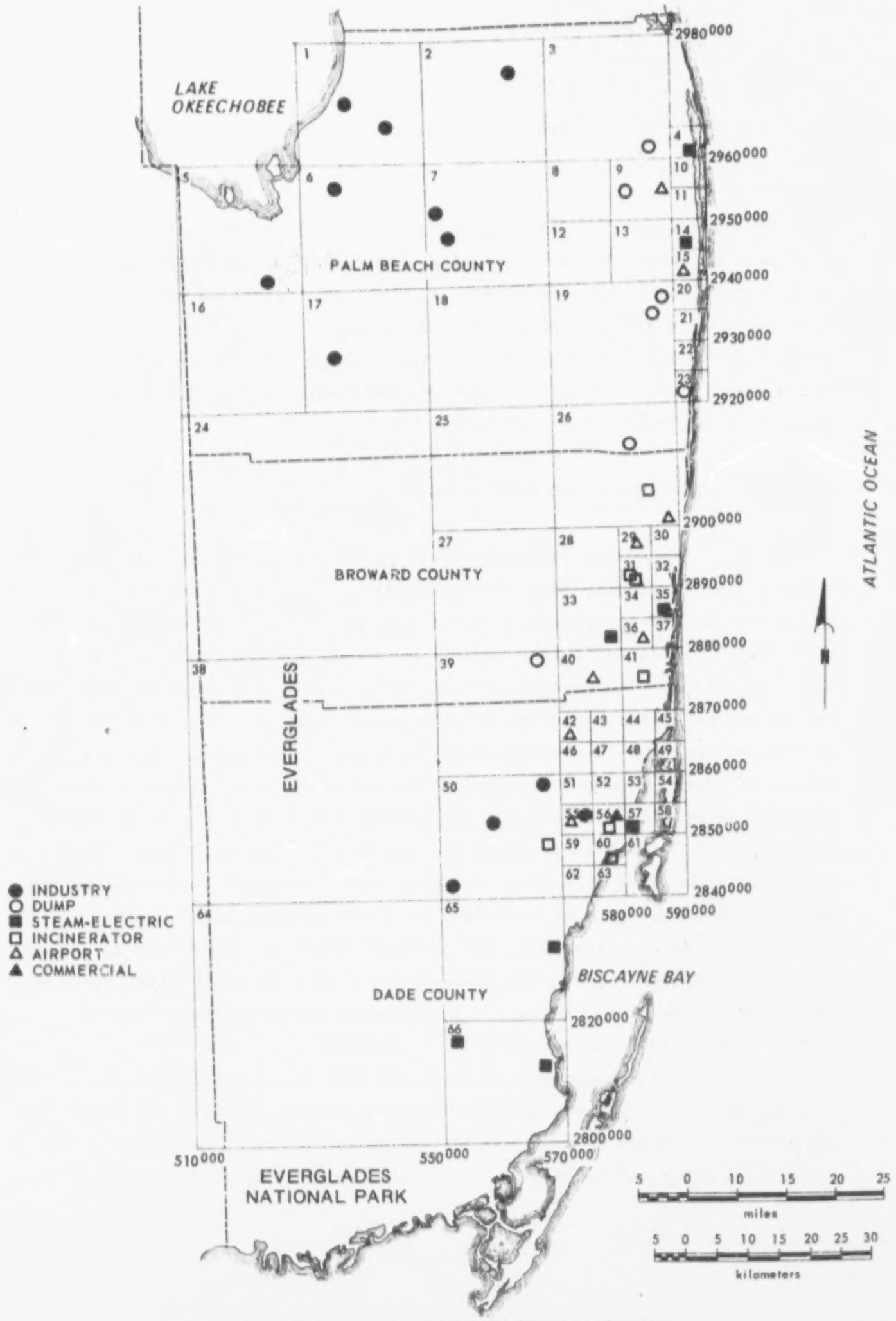

Figure 5. Point source location for Miami study area.

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES FOR THE MIAMI STUDY AREA, 1968 (TONS/DAY)

Source Category	Grid	HC	VC	SOx			PART.			CO			HC			NOx		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Industrial	1	5450	29652	0.3	0.7	0.4	17.52	17.54	17.52	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.12	0.08
Industrial	1	5370	29690	0.0	0.0	0.0	6.04	6.04	6.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Industrial	2	5620	29750	3.6	6.0	4.3	0.35	0.59	0.42	0.04	0.06	0.04	0.04	0.06	0.04	1.48	2.44	1.74
Dump	3	5864	29618	0.0	0.0	0.0	0.17	0.17	0.17	0.91	0.91	0.91	0.32	0.32	0.32	0.11	0.11	0.11
Steam-Electric	4	5942	29609	107.4	76.7	75.6	3.07	2.19	2.16	0.01	0.00	0.00	0.86	0.61	0.60	37.89	27.06	26.69
Industrial	5	5240	29410	0.7	1.3	0.9	13.34	13.38	13.35	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.25	0.16
Industrial	6	5350	29551	0.2	0.5	0.3	21.01	21.02	21.01	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.09	0.05
Industrial	7	5505	29510	0.1	0.3	0.2	2.91	2.91	2.91	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06	0.03
Industrial	7	5530	29460	0.4	0.6	0.5	1.41	1.42	1.42	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.12	0.09
Dump	9	5832	29552	0.0	0.0	0.0	0.28	0.28	0.28	1.52	1.52	1.52	0.53	0.53	0.53	0.19	0.19	0.19
Airport	9	5890	29525	0.0	0.0	0.0	0.49	0.49	0.49	9.81	9.81	9.81	2.34	2.34	2.34	0.79	0.79	0.79
Steam-Electric	14	5922	29451	0.2	0.1	0.1	0.06	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.44	1.03	1.01
Airport	15	5910	29420	0.0	0.0	0.0	0.01	0.01	0.01	3.12	3.12	3.12	0.60	0.60	0.60	0.14	0.14	0.14
Industry	17	5340	29270	0.3	0.5	0.3	9.36	9.38	9.37	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.06
Dump	19	5875	29375	0.0	0.0	0.0	0.10	0.10	0.10	0.56	0.56	0.56	0.19	0.19	0.19	0.07	0.07	0.07
Dump	19	5818	29362	0.0	0.0	0.0	0.11	0.11	0.11	0.61	0.61	0.61	0.21	0.21	0.21	0.07	0.07	0.07
Dump	23	5919	29230	0.0	0.0	0.0	0.11	0.11	0.11	0.61	0.61	0.61	0.21	0.21	0.21	0.07	0.07	0.07
Dump	26	5826	29147	0.0	0.0	0.0	0.17	0.17	0.17	0.91	0.91	0.91	0.32	0.32	0.32	0.11	0.11	0.11
Incinerator	26	5847	29058	0.2	0.2	0.2	1.03	1.03	1.03	0.12	0.12	0.12	0.03	0.03	0.03	0.24	0.24	0.24
Airport	26	5887	29030	0.0	0.0	0.0	0.02	0.02	0.02	5.30	5.30	5.30	1.03	1.03	1.03	0.24	0.24	0.24
Airport	29	5832	28975	0.0	0.0	0.0	0.25	0.25	0.25	12.73	12.73	12.73	2.43	2.43	2.43	0.70	0.70	0.70
Incinerator	31	5815	28915	0.4	0.4	0.4	1.91	1.91	1.91	0.22	0.22	0.22	0.06	0.06	0.06	0.44	0.44	0.44

TABLE 17 SUMMARY OF AIR POLLUTANT EMISSIONS FROM POINT SOURCES (cont.)

Source Category	Grid	HC	VC	SOx			PART.			CO			HC			NOx		
				S	W	A	S	W	A	S	W	A	S	W	A	S	W	A
Incinerator	31	5819	28909	0.2	0.2	0.2	0.85	0.85	0.85	0.10	0.10	0.10	0.02	0.02	0.02	0.20	0.20	0.20
Steam-Electric	33	5797	28831	19.8	14.1	13.9	0.67	0.48	0.47	0.00	0.00	0.00	0.15	0.11	0.11	9.85	7.03	6.94
Steam-Electric	35	5874	28852	203.3	145.2	143.2	5.90	4.22	4.16	0.02	0.01	0.01	1.63	1.16	1.15	73.82	52.72	52.00
Airport	36	5846	28837	0.0	0.0	0.0	0.59	0.59	0.59	48.80	48.80	48.80	9.61	9.61	9.61	2.56	2.56	2.56
Dump	39	5669	28797	0.0	0.0	0.0	0.43	0.43	0.43	2.32	2.32	2.32	0.82	0.82	0.82	0.30	0.30	0.30
Airport	40	5762	28759	0.0	0.0	0.0	0.11	0.11	0.11	21.87	21.87	21.87	4.26	4.26	4.26	1.01	1.01	1.01
Incinerator	41	5819	28755	0.2	0.2	0.2	2.30	2.30	2.30	0.13	0.13	0.13	0.04	0.04	0.04	0.27	0.27	0.27
Airport	42	5723	28657	0.0	0.0	0.0	0.31	0.31	0.31	43.20	43.20	43.20	8.31	8.31	8.31	2.06	2.06	2.06
Industry	50	5674	28582	0.6	1.1	0.7	0.25	0.28	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.19	0.14
Industry	50	5520	28420	8.8	8.8	8.8	14.30	14.30	14.30	0.04	0.04	0.04	0.04	0.04	0.04	1.59	1.59	1.59
Industry	50	5570	28520	10.2	10.2	10.2	17.59	17.59	17.59	0.05	0.05	0.05	0.05	0.05	0.05	1.86	1.86	1.86
Incinerator	50	5683	28479	0.2	0.2	0.2	1.22	1.22	1.22	0.14	0.14	0.14	0.04	0.04	0.04	0.28	0.28	0.28
Airport	50	5627	28483	0.0	0.0	0.0	0.24	0.24	0.24	39.95	39.95	39.95	7.62	7.62	7.62	1.89	1.89	1.89
Industry	55	5743	28539	0.4	0.8	0.5	0.17	0.18	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.15	0.11
Airport	55	5718	28534	0.0	0.0	0.0	2.74	2.74	2.74	26.40	26.40	26.40	8.09	8.09	8.09	3.25	3.25	3.25
Commercial	56	5788	28541	0.0	1.2	0.3	0.00	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.06
Incinerator	56	5784	28525	1.0	1.0	1.0	4.65	4.65	4.65	0.54	0.54	0.54	0.16	0.16	0.16	1.09	1.09	1.09
Steam-Electric	57	5805	28513	0.0	0.0	0.0	0.06	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	1.61	1.15	1.13
Incinerator	60	5834	28452	0.2	0.2	0.2	0.98	0.98	0.98	0.11	0.11	0.11	0.03	0.03	0.03	0.23	0.23	0.23
Steam-Electric	65	5691	28333	1.1	0.8	0.8	0.39	0.28	0.27	0.00	0.00	0.00	0.00	0.00	0.00	9.73	6.95	6.85
Steam-Electric	66	5530	28170	0.1	0.0	0.0	0.03	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.49	0.48
Steam-Electric	66	5680	28130	163.6	116.9	115.3	4.16	2.97	2.93	0.01	0.01	0.01	1.31	0.94	0.92	43.94	31.39	30.96

emissions from area sources have been added to that for point sources to obtain total emissions from all sources by grid, as shown in Table 18. The emissions from all sources are also shown for an annual average, winter and summer day.

EMISSION DENSITIES

In order to provide a visual representation of the emissions of pollutants by grids, emission density maps have been prepared. Emission densities were obtained by summing the annual area and point source emissions for each grid and dividing this total by the land area of the grid. Figures 6 through 10 show the variation in emission densities for the respective grids throughout the Study Area. As expected the emissions generally follow the pattern and degree of urbanization. Emission densities for carbon monoxide are higher in the grids with the higher populations and corresponding higher vehicular activity. The particulate emission density map corresponds fairly well with the point source location map. The highest concentration of particulates are found in those grids which contain steam-electric plants or large industrial sources. The outlying area in Palm Beach County is high in particulate concentrations due to sugar cane operations. Sulfur oxide and nitrogen oxide emission densities are highest in grids 4, 35, and 57 because of the steam-electric utilities located in these grids. Hydrocarbon emissions generally follow the degree of urbanization in an area. However, because of the inclusion of the methane from swamp gas, hydrocarbon emissions are highest in the everglades region and generally away from the urbanized area.

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES IN THE MIAMI CITY STUDY AREA, 1968

(Tons/Day)

Grid	Land Area (Sq. Mi.)	SOx			PART.			CO			HC			NOx		
		S	W	A	S	W	S A	S	W	A	S	W	A	S	W	A
1	154.4	0.4	0.8	0.5	24.7	24.7	24.7	7.3	7.7	7.4	94.1	94.1	94.1	0.3	0.4	0.3
2	154.4	3.7	6.1	4.3	0.4	0.6	0.4	0.8	1.6	1.1	233.2	233.2	233.2	1.5	2.6	1.8
3	154.4	0.2	0.3	0.2	0.5	0.8	0.6	27.0	52.8	35.6	191.3	191.3	191.3	1.9	3.7	2.5
4	9.6	107.7	77.5	76.1	3.4	2.8	2.6	27.7	55.1	36.8	5.2	7.8	5.9	39.1	30.0	28.4
5	154.4	0.7	1.4	0.9	14.4	14.5	14.5	7.0	7.2	7.1	94.0	94.1	94.0	0.3	0.5	0.4
6	154.4	0.3	0.5	0.3	25.2	25.2	25.2	26.9	27.6	27.1	189.3	189.3	189.3	0.6	0.7	0.7
7	154.4	0.7	1.1	0.8	7.5	7.5	7.5	22.8	26.2	24.0	236.0	236.0	236.0	0.8	1.1	0.9
8	38.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	69.8	69.8	69.8	0.1	0.1	0.1
9	38.6	0.2	0.5	0.3	1.3	1.6	1.4	28.3	44.9	33.8	29.3	31.7	30.1	2.3	3.8	2.7
10	9.6	0.3	1.0	0.5	0.3	0.7	0.4	35.1	69.7	46.7	5.0	8.2	6.1	1.2	3.0	1.7
11	9.6	0.5	1.4	0.7	0.4	0.9	0.6	46.3	91.9	61.5	6.8	10.9	8.1	1.5	4.0	2.3
12	38.6	0.0	0.1	0.0	0.1	0.1	0.1	4.6	9.2	6.1	70.5	71.1	70.7	0.4	0.7	0.5
13	38.6	0.2	0.4	0.3	0.4	0.7	0.5	29.9	59.4	39.7	5.5	9.7	6.9	2.1	4.1	2.8
14	9.6	0.7	1.5	0.9	0.5	1.0	0.7	47.6	94.6	63.3	7.0	12.0	8.7	3.5	5.9	3.9
15	9.6	0.4	1.1	0.6	0.5	0.8	0.6	28.5	52.8	36.6	5.4	8.3	6.4	1.6	3.6	2.2
16	154.4	0.0	0.0	0.0	1.0	1.0	1.0	6.5	6.5	6.5	256.8	256.8	256.8	0.1	0.1	0.1
17	154.4	0.3	0.6	0.4	13.5	13.5	13.5	26.1	26.1	26.1	259.1	259.1	259.1	0.6	0.6	0.6
18	154.4	0.0	0.0	0.0	3.1	3.1	3.1	19.5	19.5	19.5	258.3	258.3	258.3	0.4	0.4	0.4
19	154.4	0.2	0.4	0.3	0.6	0.9	0.7	29.5	57.5	38.9	146.7	146.7	146.7	2.2	4.1	2.8
20	9.6	0.2	0.6	0.3	0.2	0.4	0.3	13.3	26.2	17.6	2.6	4.3	3.2	0.9	2.0	1.2
21	9.6	0.1	0.4	0.2	0.2	0.3	0.2	9.1	17.9	12.0	2.0	3.1	2.4	0.6	1.5	0.9
22	9.6	0.6	0.7	0.7	0.2	0.3	0.2	10.3	20.4	13.7	2.1	3.4	2.6	0.7	1.3	0.9

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES (cont.)

Grid	Land Area (Sq. Mi.)	SOx S	SOx W	SOx A	PART. S	PART. W	PART. A	CO S	CO W	CO A	HC S	HC W	HC A	NOx S	NOx W	NOx A
23	9.6	0.1	0.3	0.2	0.2	0.4	0.3	10.8	20.9	14.2	1.9	3.2	2.3	0.7	1.5	1.0
24		0.0	0.0	0.0	2.1	2.1	2.1	13.0	13.0	13.0	920.6	920.6	920.6	0.3	0.3	0.3
25	154.4	0.0	0.0	0.0	4.2	4.2	4.2	26.1	26.1	26.1	215.9	215.9	215.9	0.5	0.5	0.5
26	154.4	1.3	2.0	1.5	2.6	3.3	2.8	117.8	182.2	134.8	111.3	111.3	111.3	9.1	14.2	10.4
27	154.4	0.1	0.1	0.1	0.4	0.4	0.4	0.6	0.8	0.6	238.2	238.2	238.2	0.1	0.1	0.1
28	38.6	0.2	0.3	0.2	0.3	0.5	0.4	27.3	38.2	29.4	68.9	70.5	69.2	2.2	3.0	2.4
29	9.6	0.1	0.1	0.1	0.4	0.4	0.4	23.5	27.7	24.3	4.2	4.8	4.3	1.4	1.7	1.5
30	9.6	0.5	0.6	0.6	0.4	0.6	0.4	48.8	68.1	52.4	7.9	10.2	8.3	2.6	3.6	2.8
31	9.6	0.8	0.9	0.8	3.1	3.2	3.1	26.2	36.5	28.2	5.9	7.2	6.1	2.4	3.0	2.5
32	9.6	1.1	1.2	1.1	0.8	1.0	0.8	113.9	159.2	122.5	14.1	18.9	15.0	4.8	6.6	5.1
33	38.6	20.1	14.5	14.3	1.1	1.1	1.0	38.3	53.6	41.2	39.3	41.6	39.7	12.9	11.3	10.2
34	9.6	0.3	0.4	0.3	0.5	0.7	0.6	52.2	72.9	56.1	9.4	12.1	9.9	3.3	4.5	3.5
35	9.6	207.9	149.9	147.9	6.7	5.2	5.0	85.9	120.0	92.4	12.2	15.3	12.4	78.0	58.3	56.5
36	9.6	0.1	0.1	0.1	0.7	0.8	0.7	58.3	62.1	59.1	11.4	11.9	11.5	3.3	3.5	3.3
37	9.6	0.8	0.8	0.8	0.3	0.3	0.3	27.3	38.2	29.4	3.9	5.1	4.1	1.5	2.1	1.6
38	617.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,042.0	1,042.0	1,042.0	0.0	0.0	0.0
39	154.4	0.2	0.5	0.3	0.8	1.1	0.9	14.5	38.3	22.4	325.9	325.9	325.9	1.3	3.1	1.9
40	38.6	0.2	0.4	0.3	0.5	0.7	0.5	54.3	69.9	57.7	95.3	97.6	95.8	3.5	4.7	3.8
41	38.6	1.1	1.8	1.3	3.2	3.7	3.4	76.4	116.6	85.8	16.2	22.0	17.6	5.8	8.9	6.6
42	9.6	0.0	0.1	0.1	0.4	0.5	0.4	49.3	61.4	53.3	10.0	11.8	10.6	2.6	3.5	2.9
43	9.6	0.1	1.3	0.5	0.3	0.8	0.4	24.8	74.4	41.3	4.8	11.3	7.0	1.7	5.0	2.8
44	9.6	0.2	1.9	0.7	0.3	1.1	0.6	32.6	97.7	54.3	6.5	15.0	9.3	2.1	6.6	3.6

TABLE 18 SUMMARY OF AIR POLLUTANT EMISSIONS FROM ALL SOURCES (cont.)

Grid	Land Area (Sq. Mi.)	SOx S	SOx W	SOx A	PART. S	PART. W	PART. A	CO S	CO W	CO A	HC S	HC W	HC A	NOx S	NOx W	NOx A
45	9.6	0.1	0.7	0.3	0.3	0.7	0.4	21.9	65.7	36.5	3.3	8.5	5.0	1.5	3.9	2.3
46	9.6	0.1	1.1	0.3	0.1	0.4	0.2	9.2	27.7	15.4	2.8	5.4	3.7	0.8	2.5	1.4
47	9.6	0.1	1.6	0.5	0.2	0.8	0.4	22.5	67.6	37.6	5.1	10.9	7.0	1.6	4.8	2.6
48	9.6	0.3	1.9	0.7	0.6	1.4	0.8	38.0	113.6	63.2	7.1	17.0	10.4	2.8	7.9	4.5
49	9.6	0.1	0.3	0.2	0.2	0.4	0.3	21.5	64.3	35.8	3.0	6.9	4.3	0.8	2.2	1.3
50	154.4	20.6	25.2	21.9	34.4	35.3	34.7	57.2	91.1	68.5	193.2	193.2	193.2	7.3	11.6	8.6
51	9.6	0.2	3.3	1.0	0.2	0.9	0.4	16.3	48.8	27.1	5.2	9.8	6.8	1.4	4.7	2.5
52	9.6	0.2	3.6	1.2	0.4	1.5	0.8	59.3	177.7	98.7	10.7	23.2	14.9	2.6	8.9	4.6
53	9.6	0.4	2.6	1.0	0.6	1.6	0.9	66.1	198.0	110.0	8.9	22.9	13.6	3.2	9.0	5.1
54	9.6	0.1	3.0	0.9	0.3	0.8	0.4	38.7	116.0	64.5	4.7	11.7	7.0	1.3	4.1	2.2
55	9.6	0.7	2.1	1.1	3.3	4.1	3.6	56.1	115.3	75.8	13.6	22.0	16.4	6.2	11.1	7.8
56	9.6	1.7	7.0	3.2	5.2	6.6	5.7	77.5	231.2	128.7	13.2	29.4	18.6	4.4	12.2	6.9
57	9.6	0.7	6.8	2.4	1.5	3.1	2.0	141.6	423.9	235.7	16.7	42.3	25.2	7.3	16.4	10.0
58	9.6	0.2	2.7	0.9	0.6	1.0	0.7	30.5	90.9	50.6	5.2	10.7	7.0	1.8	4.0	2.5
59	9.6	0.1	2.1	0.7	0.3	1.0	0.5	22.3	66.7	37.1	5.9	12.2	8.0	1.7	5.7	3.0
60	9.6	0.4	2.7	1.1	1.4	2.1	1.6	28.8	86.0	47.9	7.1	14.5	9.6	2.2	6.6	3.6
61	154.4	0.4	0.5	0.4	1.0	1.1	1.0	11.4	33.2	18.7	3.0	5.6	3.9	2.4	3.5	2.7
62	9.6	0.1	1.3	0.4	0.2	0.5	0.3	10.2	30.7	17.1	3.3	6.2	4.2	0.9	2.8	1.5
63	9.6	0.1	0.2	0.1	0.2	0.4	0.3	12.3	36.9	20.5	1.8	5.0	2.9	1.0	2.4	1.4
64	617.7	0.1	0.3	0.2	0.2	0.5	0.3	13.6	40.8	22.7	934.7	934.7	934.7	1.2	3.5	1.9
65	154.4	1.5	4.0	2.0	0.8	1.3	0.9	15.4	46.3	25.7	6.4	11.1	7.9	11.1	11.9	9.3
66	154.4	164.0	117.5	115.7	4.5	3.6	3.3	12.4	37.1	20.6	180.0	180.0	180.0	45.6	34.8	33.1

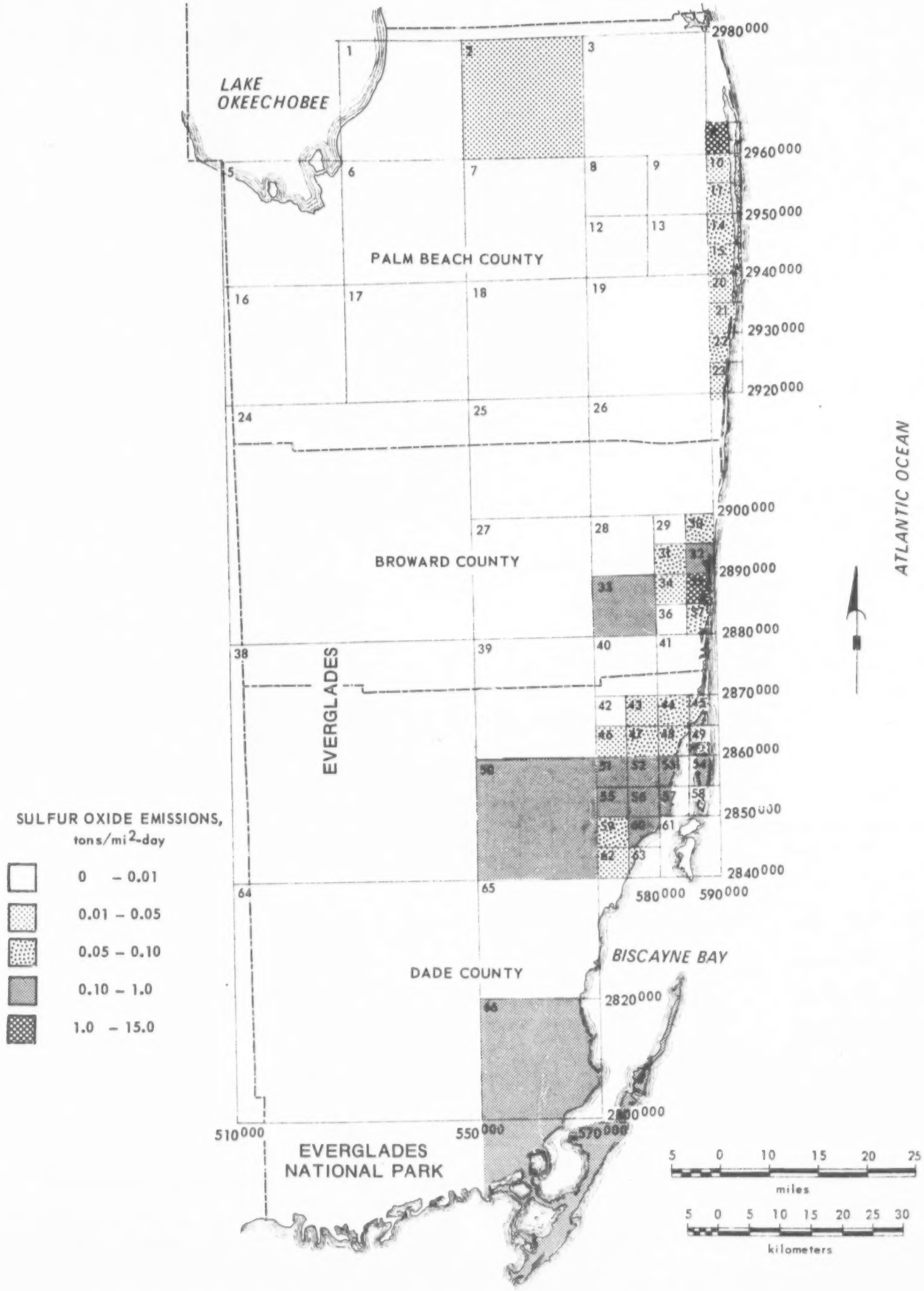

Figure 6. Sulfur oxides emission densities from air sources in Miami study area.

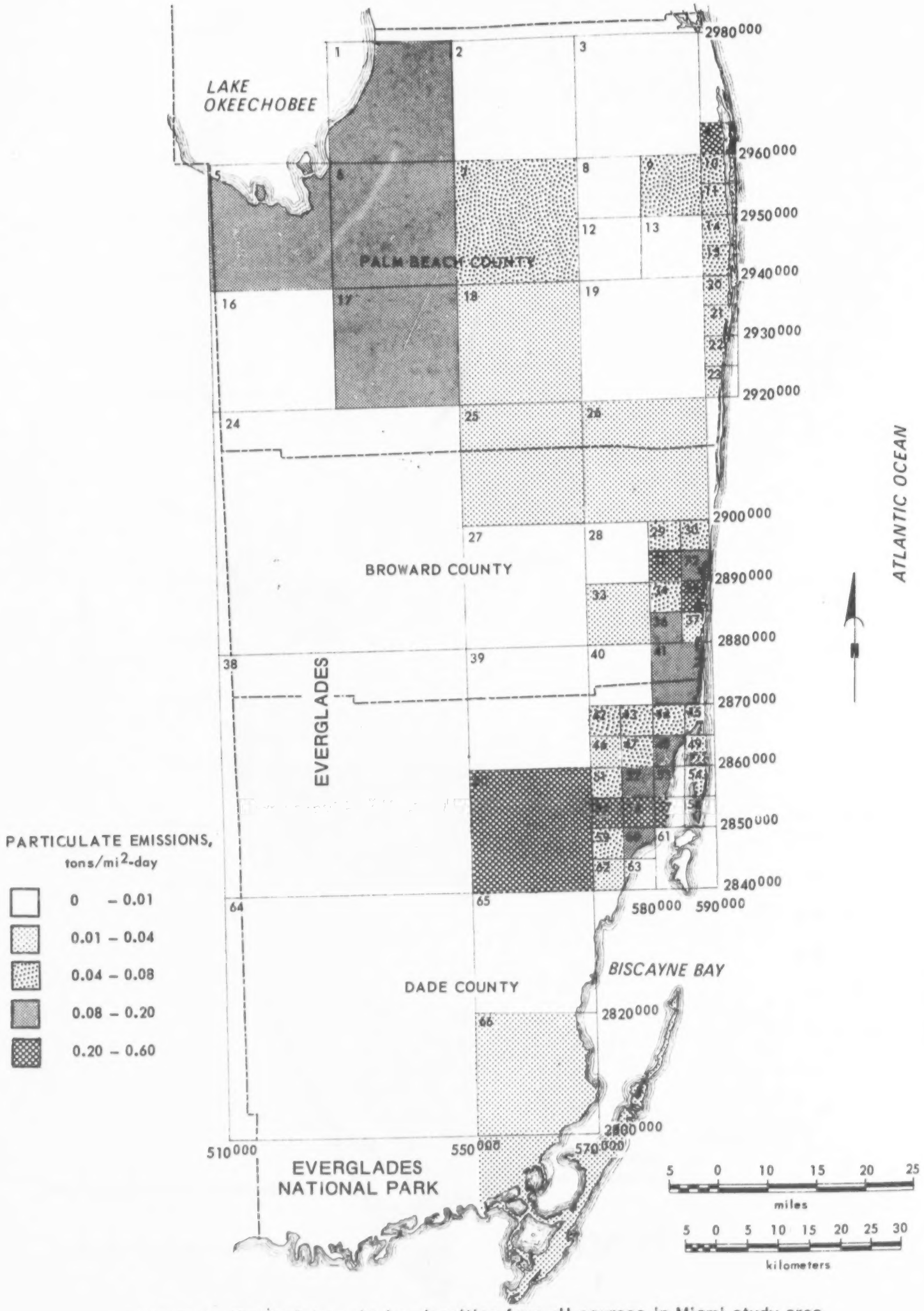

Figure 7. Particulate emission densities from all sources in Miami study area.

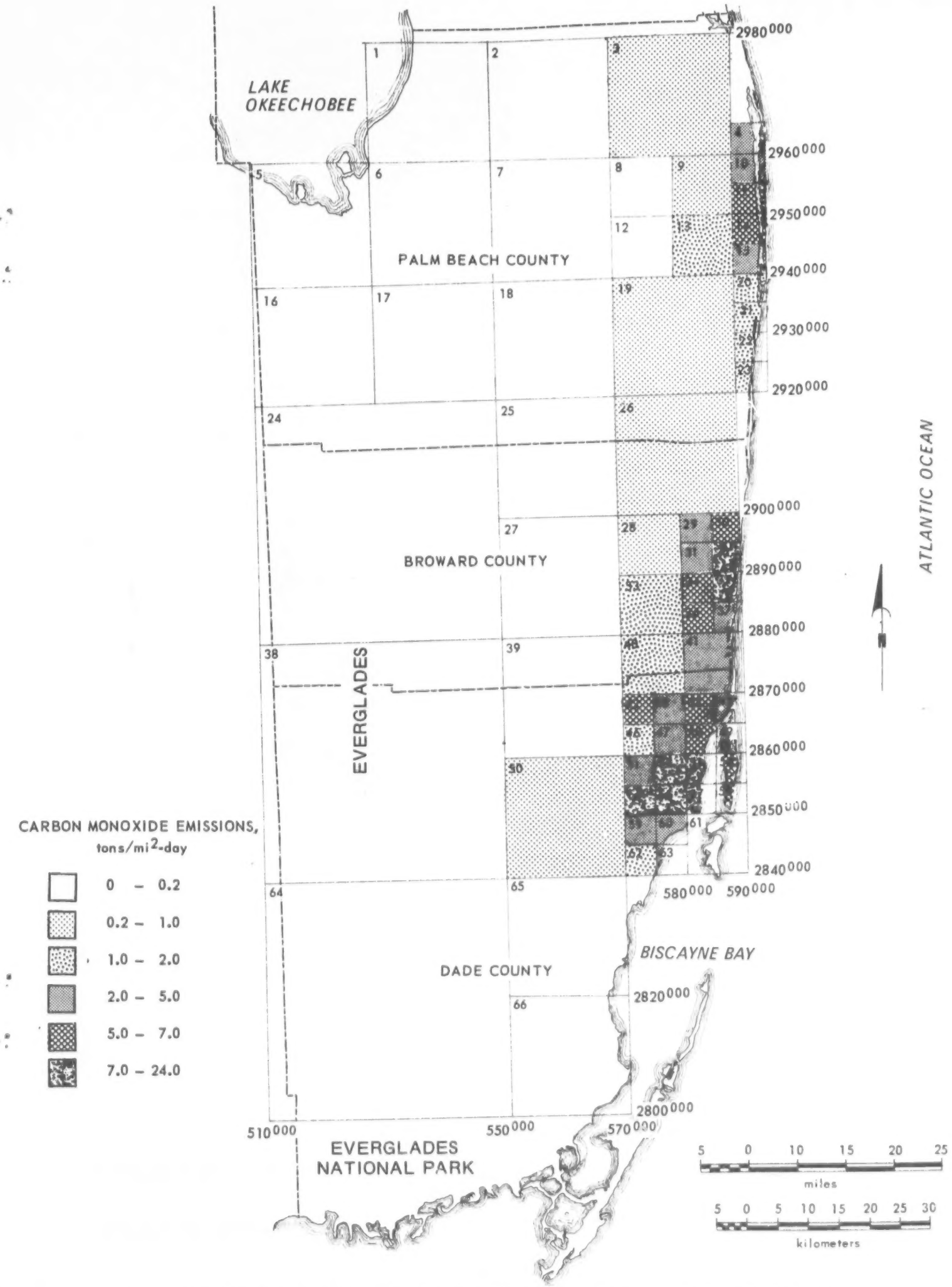

Figure 8. Carbon monoxide emission densities from all sources in Miami study area.

NOT REPRODUCIBLE

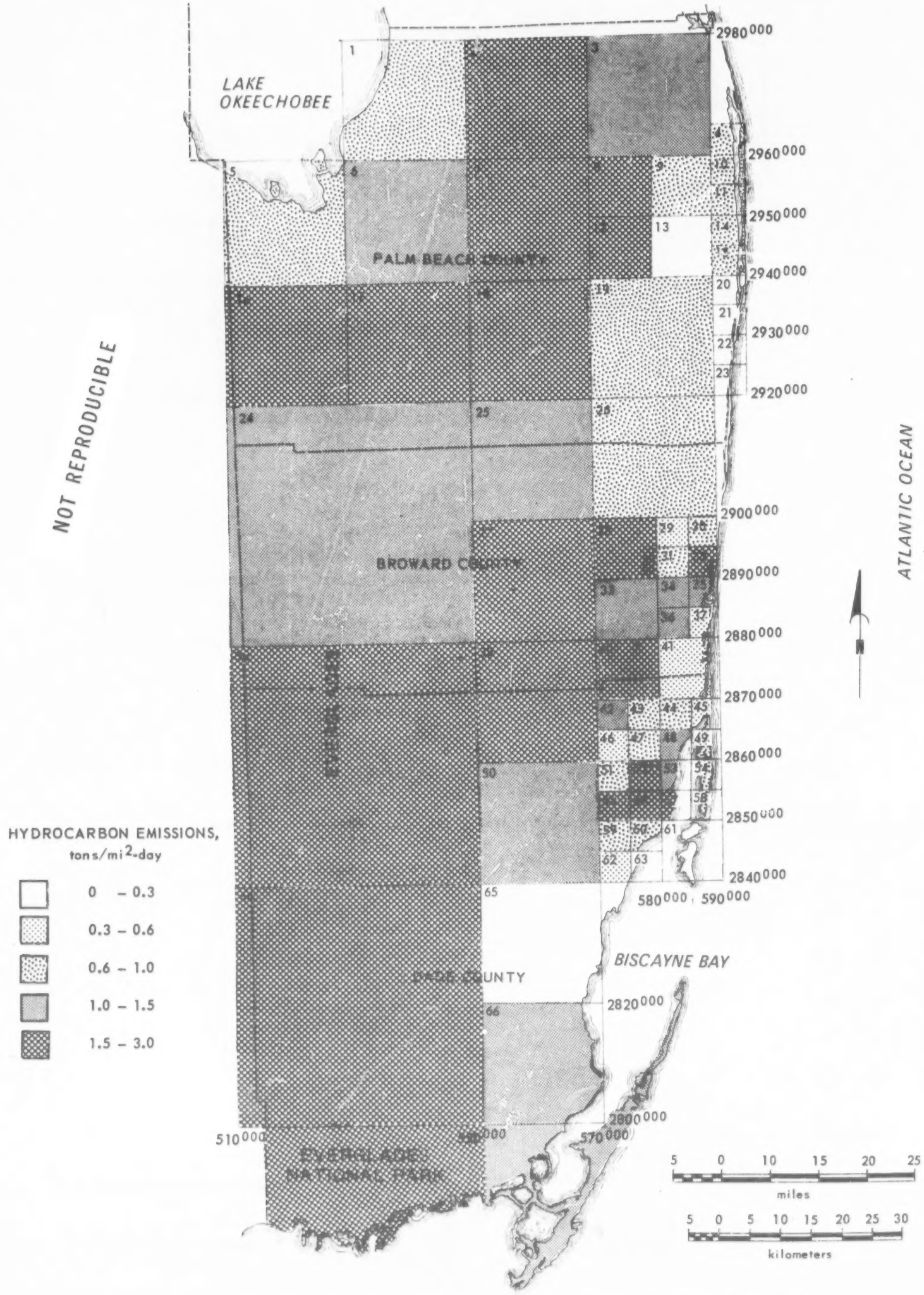

Figure 9. Hydrocarbon emission densities from all sources in Miami study area.

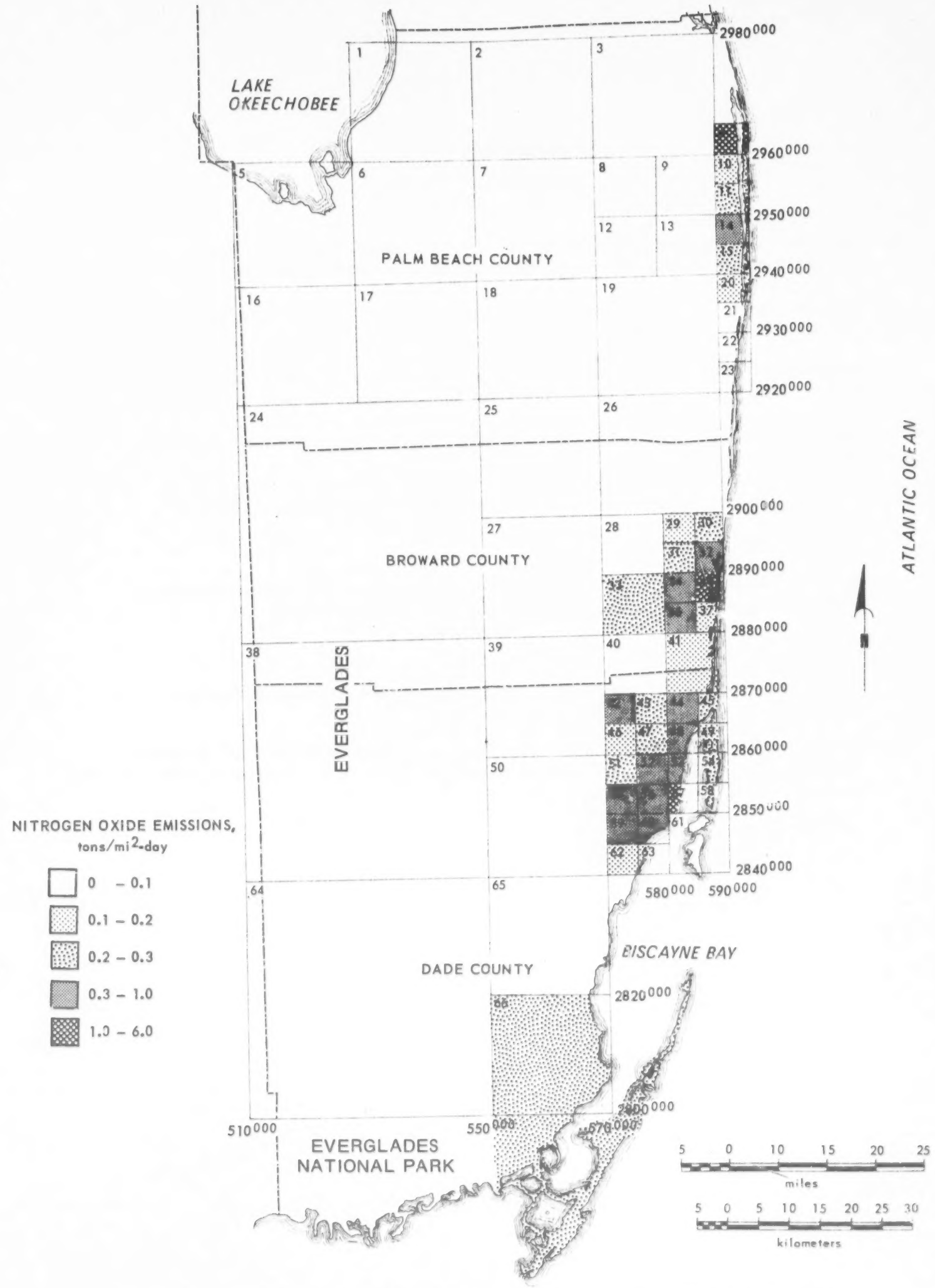

Figure 10. Nitrogen oxide emission densities from all sources in Miami study area.

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METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E.F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$